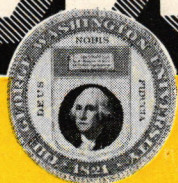


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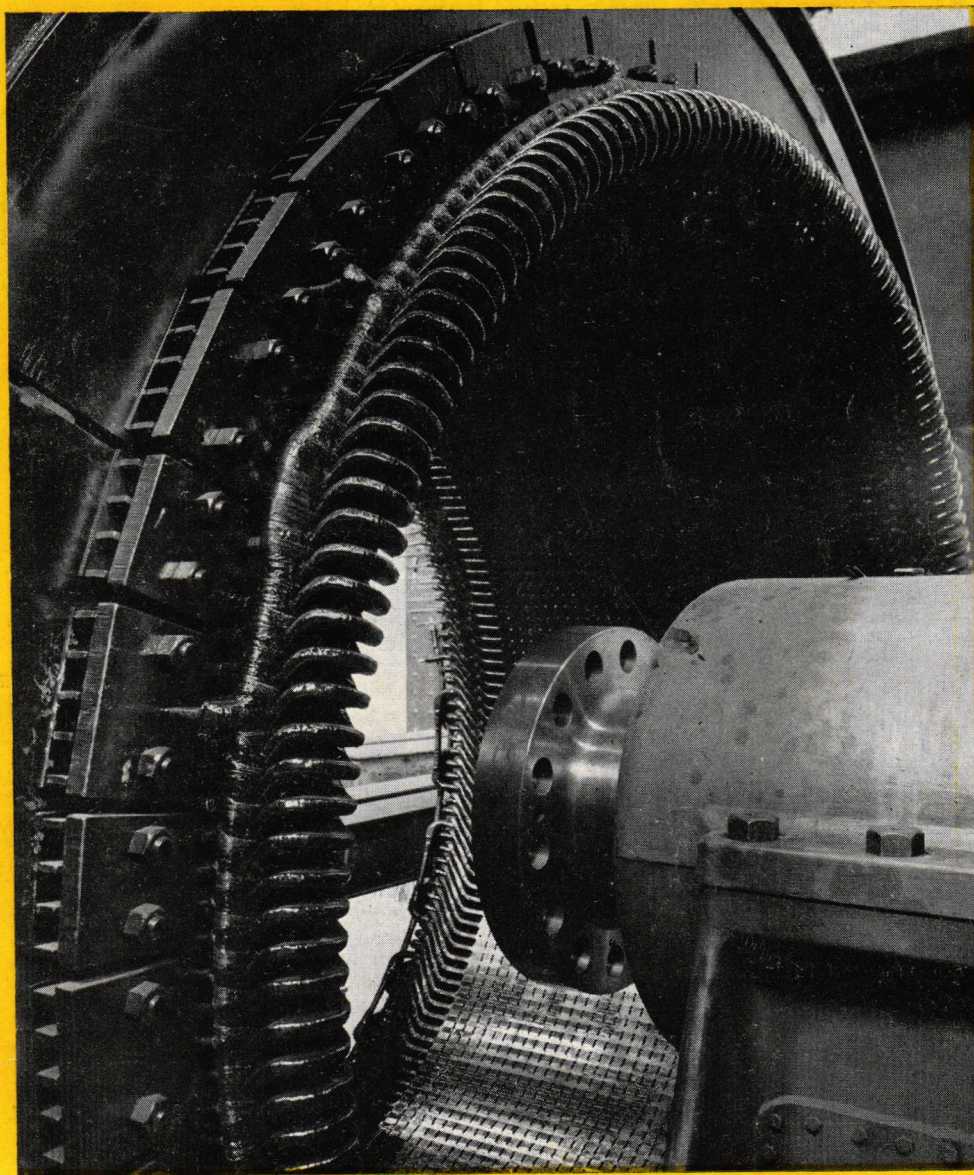


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## THE YEAR AHEAD IN ENGINEERING

by Dean Frederick M. Feiker

This coming year will see a few new courses and new faces in the School of Engineering. Assistant Professor Miklofsky, a graduate of our school who is completing his work for the Doctor of Science degree at Yale, joins the civil engineering staff. Another addition to the civil engineering staff is Yale graduate Mark Kiely. During the winter term the advanced course in Strength of Materials, CE 154, will be revived.

In mechanical engineering Mr. George Jacquet becomes Professorial Lecturer in Management and will give a new course, "Production Control and Planning", ME 145. Mr. Jacquet is a consultant in management, and an engineering alumnus of the University of Illinois, with a wealth of experience in both private and public work. During the winter term another new course, ME 147—"Patent Procedures for Engineers," is projected under the sponsorship of the Patent Bar Association of Washington.

Two newcomers to the regular instruction staff join the EE department. William Dickensen, Assistant Professor, with an MS from North Carolina, adds another instructor in our communications option, and J. A. La-Hatte, a graduate of Georgia Tech, becomes an instructor full time. A new course, EE 150—"Electronic Devices Laboratory", will be given in the winter term.

Funds have been provided for additional equipment and facilities for the communications laboratory. A new hydraulic laboratory and the remodeling and the addition of new equipment in our mechanical engineering laboratory are in the blue print stage.

Entering freshmen as well as prospective graduates and alumni may be interested to know that last year's enrollment in engineering, 1100, was the largest in the history of the School of Engineering. The graduating classes in February and June of this year established a similar record. Engineering enrollment was divided percentage-wise as follows: CE 15 percent, ME 30 percent, EE 40 percent, and BS in Engineering 15 percent.

In the spring of this year our school was visited by an accreditation committee of the Engineer's Council for Professional Development. This agency is charged with the responsibility of establishing and maintaining by inspection standards of instruction and facilities for engineering curricula in the 150 engineering schools of college level in the United States and Canada. In this inspection our courses in civil, mechanical, and electrical engineering were again accredited. We were complimented on our faculty and educational standards. The committee made a number of suggestions for the development of our physical facilities.

We invite all students of engineering to think of themselves as entering a profession. Behind the complex military and civilian life in the city of Washington and its immediate environment there are more than 35,000 civilian engineers making the wheels turn. It is this quietly substantial working profession upon which rests civil life as well as military achievement. You are entering an honorable calling with satisfactions beyond money for those who succeed.

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## THE MECHELECIV

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## ● EDUCATED ENGINEERS?

For some time now the conviction has been growing on us that something is lacking in the curricula offered by engineering schools these days. The engineer who has a variety of interests is rarer than an "A" in Physics, and the surest way to ruin a good party is to mention anything about construction or mechanical or electrical devices in the presence of an engineer. The study of engineering seems to have sunk from college level to trade-school level, and the universities go on grinding out these one-track minds at a really depressing rate.

Two things are wrong with the way in which fledgling engineers are processed by our schools.

The first and most important error is the omission from the curriculum of many of the essential arts courses. A very interesting article by R. G. Daniels, a fellow student at George Washington, discusses this aspect of the subject and proposes one way to give future engineers the education which seems to have eluded so many diploma owners. Excerpts from his article follow:

"College should be looked upon as a preface to living. The life is an empty one in which one's interest begins and ends in the pursuit of a trade, be it law, accounting, engineering, or what-have-you. Everyone needs a broader grasp of our present civilization, and such a knowledge is covered by a much misused work—culture.

"Culture doesn't mean knowing where the dirty parts of Shakespeare's plays are; it means an un-

derstanding of the factors that have produced our present way of life. . . . An educated point of view makes our whole world more meaningful. The theories of the economist Malthus serves to make the poverty and recurring famine of India a more understandable situation, while history and literature combine to explain the force of events and the temperament of a people that might lead them to accept a creed such as fascism in Germany, or the socialism which grasps Russia. The political scientist gives us an explanation of what these organizations expect (or expected) to accomplish.

"History doesn't ignore engineering, either. The industrial revolution didn't occur overnight. James Watt didn't start a fire under a boiler and decide to have a steam engine on the spur of the moment; this was the culmination of forces beginning even before the time of the ancients, when Archimedes slopped the water out of his bathtub. The guided missiles field is making rapid strides these days, but people were experimenting with rockets in China while Confucius was busy writing precepts a thousands years ago. . . .

"All of us have seen or heard statistics which show that reasons for failure in the field of engineering are personality and adjustment difficulties more often than technical deficiencies. We can assume that schools are doing a satisfactory job of teaching engineering fundamentals, and probably none of us would honestly want to reduce the time spent on these essential subjects. On the other hand, there seems to be no spare time in any semester into which the study of the arts, or humanities, as they are sometimes called, can be fitted. . . .

"The only solution, it seems to me, is to add more time to the total curriculum, and the minimum additional time appears to be one year. . . ."

We thoroughly agree with this analysis of the need for some change in the curriculum, and with the solution suggested. If we were picking the most valuable courses to fill this additional 36 semester hours, we would choose the following: History 39-40 and 71-72 (12 hours); Political Science 9-10 (6 hours); Foreign Language (6 hours); English 51-52 or 71-72 (6 hours); Sociology 1 or Psychology 1 (3 hours); and three hours elective to be taken in the Junior College.

Before the anguished screams arise, let us add that we think that the engineer who spent 36 hours taking these courses would find them among the most valuable time he spent in the entire five years.

The second error in the present educational pro-



gram is the total lack of emphasis on extra-curricular activities. Unless some public-spirited professor gives his students the word on this important phase of college life no one ever hears of this vital part of education except from harassed student leaders trying to recruit some help or drum up school spirit.

We know one recent graduate who tells with evident pride that he was a student at George Washington for two years without attending a single student activity, with the one exception of an Engineers' Ball to which he was dragged by his wife. This graduate didn't even bother to see a football or basketball game. He says he came here to study. To paraphrase Sir Walter Scott, "Breathes there a man so dead?"

A system which produces citizens such as the one described above is no educational system at all. This graduate is, we hope, an extreme case, but there is good reason to believe that many engineers leave college with a fine training in a specialized field, a narrow range of interests, and no practice in the valuable art of getting along with people.

The best remedy for the familiar "grind" is a good dose of extra-curricular activities. A student who has participated in these valuable adjuncts to his formal education finds that they pay rich dividends in friends

and experience, and he leaves the University with some preparation for the give-and-take of practical engineering in the world in which he must make his living.

We'd like to see an Engineers' team in each of the intramural sports. We had some good baseball teams once, and maybe some of the slide-rule handlers around the campus can also handle a football. We also think it would be a fine thing to have an enlarged Engineers' social program, and to have more engineers in campus politics. There is a crying need for energetic, forceful students with a flair for leadership to give us a start in the right direction.

We feel so strongly that every student should be shown the value of activities of this type that we recommend that the University in general and the Engineering School in particular consider the student's interest and participation in student affairs when evaluating his fitness for graduation.

If you graduate without most of the essential arts courses in your background and a record of indifference toward student affairs, you are cheating yourself, the University, and your fellow students. You are cheating yourself the most.

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## from the editor's mailbox

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*This space is intended to serve as a forum for student opinion. Opinions expressed are those of the writers, and not necessarily those of the MECHELECIV. Address communications to: Editor's Mailbox, the Mecheleciv, Bender Bldg., George Washington University.*

—THE EDITORS.

Dear gentlemen,

From our first days as student engineers we are constantly reminded of the benefits to be obtained by membership and active participation in the professional societies.

This is without doubt a fine idea but the whole program is being "hamstrung" by a few professors who insist upon giant homework assignments on the monthly meeting nights, or worse yet upon a quiz on the following day. I fully realize that a certain amount of material must be covered each day, but I also feel that the day's program could be carried out just as well with a reading assignment only and the problem assignment carried over one day.

The engineering societies have been worrying for years about getting men out to the meetings and I believe that a light study program on the first Wednesday of each month would solve the problem. The policy of course would have to

have the support of not only the Engineering professors but also those in the Mathematics and Physics Departments. The Physics department is one of the worst offenders. They invariably schedule their exams on the first Thursday of each month, and few of us can afford to bypass a short review.

While this letter is addressed to the Mecheleciv, the successful initiation of this policy will require the support of every engineer on campus and the sincere endorsement of all their organizations. The coming semester is the ideal time to get started, so if I have any backers, let's get started and put it across.

B. C. E.

• *You're right in there pitching, B.C.E. This has been a sore spot for years, but no energetic champion has really fought for us. We hope you do your stuff.*—Ed.

Dear Editor:

Why don't you make the Presidents of the engineering societies get to work and plan a good program with good technical speakers, plenty of interesting field trips, and a good social program. Every year it's the same way a bunch of new officers are elected in the spring time with great ideas as to what should be done to increase interest and participation.

What happens? After a few weeks of gassing about what they'll do next year they go into hibernation for the summer. Along comes registration for the Fall semester and nothing has been done. Then comes the complaint from the foolish loyal society members of the lack of interest in the societies. Who could be interested in a society that offers nothing to their members except a hastily prepared program that wouldn't even interest a kindergarten class?

I've attended GWU for three years now and I'm not going to join a society until they offer a good thought-out program that interests an engineering student. It's about time that the officers took their responsibilities seriously and did a little of their planning ahead of time so that the fellows who might join would know that the society will not just waste their valuable study time. After all if the officers don't know what they are trying to do the just plain members can never expect to get anything done.

I think something should be done, but it looks like I'll graduate long before we have any good societies at GWU.

—Disgusted Senior

• *Things aren't really this bad, are they? Let's give this year's crop of new officers a chance.*—Ed.



# A New 45-rpm Recording System

By Gerald L. Warner

January 10, 1949, the RCA Victor Division of the Radio Corporation of America announced the development of a radically new type of record and record player. This new system of 45 rpm records and matched record players, the culmination of a decade of research and development, was a further indication of a new and important trend toward high-fidelity and distortion-free reproduction of recorded music in the home.

J. G. Wilson, executive vice-president in charge of RCA Victor Division, stated that the planning was based on the belief that the 45 rpm reproducing system and record are of an evolutionary rather than a revolutionary nature. The old problems of record standardization, including thickness, diameter, groove depth, and other factors varying among manufacturers are solved by this new system. All classifications of music are on a single disc size, 6- $\frac{1}{8}$  inches in diameter and capable of playing for five minutes and fifteen seconds. The record playing equipment and record were expressly designed for each other in a system designed to provide mechanical simplicity, small size, light weight, and lowered costs.

It is the purpose of this paper to describe briefly the record changer design and operation, details of the record design, the tone factors embodied in the new system, and the economic impact caused by the commercial introduction of the system. Finally, a brief comparison to a competing system of long playing microgrooved records will be made.

## Record Changer Design

Simplification of record changer design has been achieved by RCA Victor for its new 45 rpm system of reproduction. The base, containing the motor and part of the automatic record changing mechanism, is extremely compact and may be housed in a relatively small case, or, housed in a console, will result in as much as 25% size reduction. The shaft of the single speed 45 rpm motor is precision built to insure constant running speed and eliminate turntable "wow." The radical feature of the system is the center spindle, a 1 $\frac{1}{2}$ -inch diameter red plastic-topped post containing the automatic record changing mechanism.

Extreme speed of record changing is a notable feature of this system. Immediately upon completion of a record the pickup arm swings out, the next record drops in place, and the pickup arm settles into

the first groove of the record, all in the time required for the turntable to complete one revolution. This is a changing time of 1 $\frac{1}{2}$  seconds. Metal fins emerge from narrow horizontal slots in the spindle to hold the upper portion of the stack of 8 to 10 records while latch-type projections below the record recede to drop the bottom record. The action of the turntable and drop mechanism is noiseless, and the drop of a record is almost inaudible due to its lightness. A muting switch also opens the circuit automatically during a change cycle so that no noise signal voltage reaches the amplifier from the pickup arm. The action of the drop mechanism is normally automatic but records may be manually changed by means of a reject button.

The pickup arm contains a permanent sapphire point crystal pickup. The radius of the stylus is one mil (0.001 inch), that radius being best suited for the record groove width of from 2 $\frac{1}{2}$  to 3 mils (0.0025 to 0.003 inch). The tracking pressure of the stylus is 5 grams. Adjustments of the pickup arm are made by two small screws which are reached from the top. The height of arm travel above the record during the changing cycle is adjusted by one screw, while the other screw is a landing adjustment to insure that the stylus lands in the first groove of the record each time.

Forty-two to fifty-two minutes of total playing time are allowed by its eight to ten record capacity. Eight records are its best operating capacity.

## Record Design

The records for the new RCA Victor 45 rpm system of recorded music are of thin vinyl plastic or "Vinylite." Construction details are as follows. The discs are 6 $\frac{1}{8}$  inches in diameter, with a spindle hole in the center 1 $\frac{1}{2}$  inches in diameter. The thickness of the records is not uniform, having a collar in the label area thicker than the playing area. This provides air space between adjacent records in a stack so that playing surfaces do not touch and consequently do not scratch each other. The records are provided with a V-shaped indentation inside the rim of the center hole in order to fit the knives of the center post changer mechanism. The playing surface of the record is a single band approximately one inch wide containing about 275 grooves for a total playing time of five minutes and fifteen seconds. Three-minute records are made with fewer grooves but are otherwise identical to the longer playing records. The groove width is





*View of compact 45-rpm unit*

from 0.0025 inch to 0.003 inch.

Vinylite, the material from which the discs are made, is a vinyl-acetate resin molded with heat and pressure. It is unaffected by water, oil, gasoline, acids, or alkalies. Being thermoplastic, the plastic softens under the action of heat, therefore records made from it must never be stored on edge in a hot place. Tests have shown that vinylite records have a low noise level from granular irregularity and that they greatly outlast standard discs made of shellac. In a test made by C. G. Burke, the records made from vinylite were found to have such slight tonal deterioration and surface noise after 125 playings that comparison had to be made to a new record to detect these faults. Vinylite is light and strong, and the discs made from it are unbreakable. A stack of 1000 records can be housed in an ordinary console cabinet. The small size of the new records makes storage possible in an ordinary bookcase.

RCA has announced that the new discs are to be pressed in seven colors: ruby red—classical; midnight blue — semiclassical; jet black — popular; lemon-drop yellow—children's; grass green—westerns; sky blue—international; and cerise—folk music.

### **Tone Factors**

To evaluate properly the worth of RCA's new system of recording, first consideration must be given to frequency response and tone. Fidelity in recording depends mainly on minimum recording diameter, record speed, ratio of modulated to unmodulated grooves, stylus tip radius, and frequency response matching between pickup and record.

Ordinarily, high frequency response at 45 rpm is greatly reduced over that at 78 rpm. Likewise, the high frequency response will be less as the recording diameter decreases since the velocity of the recording stylus will decrease as it moves toward the center of the record. This decrease in stylus speed will cut down the length of groove available for a high frequency modulation, resulting in serious attenuation or complete loss of high musical notes. This inherent inability of lateral disc recordings to obtain a flat frequency response over the entire recorded portion led to the adoption of a record with very fine grooves (275 per inch), and the recorded portion in a band only one inch wide. These fine grooves, used with a stylus of one mil radius, allow sufficient room with a speed of 45 rpm to record signals up to 8000 cycles. The desirability of a small record with good response and a useful playing time influenced the choice of a 45 rpm speed. It was necessary that the speed be slow enough to allow a longer playing time in order to compensate for the narrow recording band. A slower speed would have necessitated either increasing the diameter of the record or losing some degree of frequency response.

The two components of sound are pure tones and complex sounds. To be classified as a true high-fidelity sound reproducing system, the record, the pickup, and the amplifier components of a phono-

*(Continued on page nineteen)*

*Console cabinet showing 45-rpm and 78-rpm units, radio, and television receiver.*





## NEWS AND VIEWS

### Dean Feiker Goes to England

Doctor Frederick M. Feiker, Dean of the School of Engineering of the University, and the educational consultant for the past 15 years for the Textile Foundation, who sponsor the National Council of Textile School Deans, has been invited by the British Cotton Textile Board to visit England with a group of the textile school deans to study methods used in British textile mills, and at the same time to discuss with distinguished British educators American methods of teaching textile production.

In discussing plans for his trip, Dean Feiker said that he will sail for England on October 6, on the Queen Elizabeth. He expects to return to the University and resume teaching on November 13. Until that time, Mr. George Jacquet will teach those courses normally taught by Dean Feiker, and will also teach a course in Production Controls that is being offered at George Washington this semester for the first time since the war.

In 1932, after months of laborious work visiting schools, textile mills, and small plants throughout the eastern part of the United States and examining in detail production methods and instructions methods, Dean Feiker prepared a report for the Textile Foundation outlining the needs in tying the instruction at the schools into production procedures at the plants. This report has since become the basis for a great deal of improvement in methods in America. The work which he will do in England will undoubtedly be an extension to that country of ideas which have proven sound in practice here.

### ENGINEERING SCHOOL CALENDAR

September - October, 1949

- Sept. 15—Thursday—Engineer's Council Meeting  
8:15 P.M., Engineers Lounge
- Sept. 28—Wednesday—Mecheleciv magazine out
- Oct. 5—Wednesday—Engineer's Mixer, 8:15 P.M., at  
Ruby Foo's, 728 13th Street
- Oct. 12—Wednesday—Theta Tau Meeting
- Oct. 13—Thursday—Engineer's Council Meeting  
8:15 P.M., Bender Building
- Oct. 19—Wednesday—Sigma Tau Meeting
- Oct. 26—Wednesday—Theta Tau Meeting
- Oct. 28—Friday—Mecheleciv magazine out

### New Engineering Offices Open

Office space has been assigned to the Engineer's Council in the newly rebuilt and redecorated Student Activities Building, well known on campus as the Bender Building. This building, beside the new Student Union, was used last year for student activities, but has been completely worked over during the summer, including installation of new fire doors, partial reconstruction, and redecorating of the rooms.

Activities sharing the use of the new Engineering room, which is the front room on the third floor, include the Council, Mecheleciv magazine, the four engineering societies, and the two fraternities. The societies and fraternities will continue to meet in classrooms, but will use the new space for office work. Mecheleciv will conduct all of its work in the new space.

The Engineer's Lounge, which is on the second floor of the Mechanical Engineering annex to Corcoran Hall, will continue to be used as a lounge.

ABOUT OUR COVER—Photo shows the stator winding of a 25,000 KW frequency changer in service in the Benning plant of PEPCO. EE-10 classes under Professor Ames visited the plant September 21 and were shown through the entire plant by PEPCO guides. This plant supplies a major part of Washington's electrical generating capacity.

### \$60,000,000 Dam Project Under Way

The Clark Hill dam project, part of a huge Savannah River development plan eventually involving eleven dams, is now well under way on the Savannah River, near Augusta, Georgia. It is expected that this dam, involving 2,000,000 cubic yards of excavation and 1,000,000 cubic yards of concrete, will have a generating capacity of 280,000 kilowatts.

Six major contracting firms have formed a single joint organization known as All States Constructors, Inc., to handle the \$26,000,000 main construction contract. Total project cost is estimated at \$60,000,000 with the entire development of the river expected to run to \$150,000,000.

Work has been proceeding on this contract for some time, and first stage spillway concrete work is completed, while construction is proceeding on the second stage cofferdam, which will enclose that part of the concrete construction including the power intake. The embankment on the South Carolina side is partly finished, as is the west embankment.



# Industrial Research In Great Britain

By Sir Robert Watson-Watt, C.B., LL.D., F.R.S.

## 1949 FRANK A. HOWARD LECTURE

*The George Washington University School of Engineering, in cooperation with the National Academy of Sciences and the National Research Council.*

*Sir Robert Watson-Watt, fourth Howard Lecturer, holds many honors, including C.B., LL.D. (St. Andrews), Fellow Royal Society, Fellow, Royal Aeronautical Society, Member, British Institute of Electrical Engineers. In 1942 Sir Robert was knighted by his King for his services in radar development. He is Scientific Advisor on Tele-communications, British Air Ministry, and Vice-Controller of Communications Equipment, Ministry of Aircraft Production. In private industry he is principal in the partnership of Sir Robert Watson-Watt and Partners, Ltd.*

Dean Feiker, Ladies and Gentlemen: Since you, sir, have already disclosed that I had breakfast this morning in a train between Toronto and Washington, I will go further in the disclosure and say that, over breakfast, I made the acquaintance of a very charming and intelligent young woman. She asked what seemed to me to be a very penetrating and thought-provoking question. My railway geography, sir, is not very good; since the Civil Aeronautics Authority encourages me to travel by air, my ground geography is weak; but I suppose we were somewhere in Pennsylvania or Maryland; and she said, "Are you going to the same Washington as we are?"

That question, from my four-and-a-half-year-old friend, suggests to me that we ought to begin by making sure that we both, in our thoughts, are going to "the same industrial research," and so I am going to try to put, in language that would have been approved by my four-and-a-half-year-old friend, my own rather low-brow definition of research, and to indicate roughly what I mean when I say "industry."

I do not think that it is necessary to put matters of that sort in the pompous language that is often thought appropriate to the auditorium and the textbook. I believe we are a little inclined to miss the essence of things when we talk in our own rather inflated and specialized language; and so I am going to venture to say that the purpose of scientific research is, essentially, to find out what happens when we do certain things to certain things; the crucial word in this unguarded definition is, of course, the word "certain." If we do uncertain things to uncertain things, we may produce art, poetry, music, history, trouble, waste, or nothing in particular; but we are certainly, in that operation, making no contribution to that very stringently and self-restricted esthetic pursuit which is called "Science."

I mentioned art, poetry, and music, specifically, because I want to say in the clearest possible terms that I regard science as an esthetic pursuit, as fundamentally

an esthetic pursuit, as one which requires no other justification than that it is esthetic, and as one which is no more and no less noble than these other pursuits that I have enumerated, art, poetry, music—which are universally recognized as being worthy and noble.

Science is the same kind of thing, and the motives I believe to be of the same kind; but it is not an unknown thing for the artist who calls himself a scientist to count himself somewhat superior (especially when he is young) to the other kinds of artists. That feeling of superiority I believe to arise principally from one or the other of two reasons, both of them bad.

The first thing is that he may forget that he has chosen to confine his artistic endeavor to a field within which the controlling adjective is that one which I have already emphasized, the adjective "certain." In doing that, he has chosen to play his game according to rules of his own writing, rules which make it much easier than it would be if the highly definite adjective were not present. That, I think, is the reason why that particular kind of scientist regards a matrix as superior to a Matisse, a correlation as being more exciting than a corregio. The real truth is that once you find a matrix, it is a very dull thing indeed, because it means the same thing to all individuals for whom it has a meaning. The Matisse (and I will admit at once I use Matisse—rather than Van Gogh, or Utrillo or Brague, only for the sake of alliteration) is exciting and important and fulfilling just because, once you have got it, it says different things to different people. They are nearly all true things, but the excitement lies in their variety and in the uncertainty of the reaction. I suggest that that is one argument in favor of a modesty not always present in the scientific researcher.

The other, and I think perhaps even worse, reason for his sense of superiority, is that he may consider that his science is useful. He may, in fact, prefer refrigerators to rhapsodies, or plastics to pastorales. That is a very soul-destroying thing. I have the utmost regard for the increasing necessities of life that arise from the operations of the scientist who does immediately useful things, but I believe that the only right attitude to take to applied science is that its usefulness is a secondary or by-product usefulness from the primary artistic pursuit.

I believe, firmly, that the release of nuclear energy is the highest achievement of the human intellect up to this moment. It is that highest achievement be-



cause it called forth exercise of the imagination, vision, ingenuity, constructive faculty, constructive action, all on a plane of the highest esthetic quality, and, therefore, giving the highest esthetic satisfaction. That this purely intellectual satisfaction resulted in the atomic bomb and will result in the application of nuclear energy to peaceful pursuits is, I believe, in the history of mankind, incidental. Indeed, in the history of civilization as a whole, I believe that these things, these applications, will continue to be incidentals, because we must remember that books are still more explosive than bombs; that more evil has been swept aside by the product of the pen than will ever be blown away by the product of the pile.

It may seem an odd thing to make this almost abstract preamble to a discussion of scientific research in its application to industry, but, if I am allowed to proceed with my definition for four-year-olds, I would—a little less confidently—define industry as the production of certain things to do certain things. In both cases, both in research and in industry, we may quite legitimately follow a converse path. We look on something which happens, and we may set about finding the certain things which produce this result. In industry, (you, sir, have already referred to the art of salesmanship; I trust that there was no personal application in your comment) in industry, it is legitimate and productive, having an already existing certain thing, to find new purposes to which it can be applied.

There is, in effect, no limit to the range of things that we demand in the making of our lives, save only the limit imposed by the price, which is not always measurable in the certain units of the account book. There is practically no limit to the things that humanity may demand in its continuous conflict with nature. The demands do not appear to even stop short of that ultimate thing, which your greatest weekly journal, *The New Yorker*, so neatly identified a week or two ago as "Omnicide." For these reasons I am justified in giving you a dazzling glimpse of the obvious by remarking that all scientific research is, in the last analysis, potential industrial research.

There were frontiers in the old thinking about science and industry. There was an odd (and an oddly offensive) kind of thing called pure research; and there was a kind of thing to which engineers were inclined to turn called industrial research; and there was a sense of superiority on the part of the pure, or academic, researcher over the putatively impure, or industrial, researcher.

Just as I have asserted my creed that science is an artistic pursuit, no more noble, no less noble than the other artistic pursuits, so I would go on to assert that what used to be called pure research is neither more noble nor less noble, no more "useful" and no less "useful" than what used to be called industrial research. As both these pursuits develop and extend, we find that any frontiers that may have been imag-

ined in the past are rapidly vanishing, if they have not vanished. The particular kind of mind which prefers to pursue research for a specific purpose is more and more in need of the products of the in-no-wise superior mind that finds its satisfaction in adding to the sum total of human knowledge, with no thought for a short-term result. Both of these modes of operation are, in fact, modes of self-expression. Both add permanently to the stature of the universal human mind. One of them may take, indeed, the form in which self-expression becomes self-indulgence. From that standpoint, it is arguable that the man who researches for specific application is less selfish than the man who researches for the fun of it, and for nothing but the fun of it. But the degree of satisfaction to the individual is governed, I suggest, by the way in which his mind was originally designed—and a benevolent Providence has spared us standardization in the shape of the human mind.

Modern industries are, I need hardly say, made, maintained, and rejuvenated by scientific research. You probably know of the financier who looked toward a scientist crossing the street and said, "There goes the man who makes my securities insecure." He was at least aware that the object of scientific research is to produce beneficent obsolescence through enrichment. He was, I hope, aware that the price of security for investments is eternal vigilance, a vigilance which maintains a watch for those things, resulting from scientific research, which may produce a new crop of further investments and securities, which may have their secure day but which, in their turn, are doomed to make way for rejuvenated industries, depending on still further progress.

There is, however, a difference amounting to a possible conflict between that kind of research which is consciously directed to a short-term purpose, and that, which is directed only toward the more general goal of knowing what the young James Clerk Maxwell called "the go of things." Specifically directed research is almost certain to produce an evolutionary advance. Research which is digging, perhaps more deeply, into the basic "go of things" will, not certainly, but very probably, produce not an evolutionary change but a revolutionary change. From that standpoint, and for another and more nearly economic reason, we have to keep a continuous watch on the balance between the activity that was formerly called pure research and the activity which was formerly called industrial research.

You here in the United States are perhaps, at the moment, less acutely sensitive to materials in short supply than we in the United Kingdom are, but I think you share with us one difficulty about a commodity in short supply. That is the commodity of scientific man power and brain power. Great institutions like yours, sir, are constantly improving the supply. But as long as scientific brain power is in short supply, there is a fundamental responsibility on all of



us concerned with scientific problems. We must watch that the application of our man power to short-term research projects is not dangerously limiting the man power which is available for the replenishment of the stockpile—the stockpile of basic knowledge of materials and the properties of those materials on which the industrial researcher must depend for his fabrication of new industrial processes and new industrial products.

What I ask for the student, who is faced with the choice between a more academic form of research or a more production-minded kind of research, is a comparatively simple and modest thing. He should be shown as fully and clearly as possible the pressure of the immediate needs of the people around him, and of the industries around him. He should be shown and inspired by the example of the people who have devoted themselves to fundamental research. He should then be left democratically free to choose for himself whether he would like to be predominantly a short-term worker or a long-term worker. And he should, above all things, be protected from the pressure, the moral pressure, which results from these tententious adjectives that we used to put in front of the word "research." He should, in fact, be given an option, with full information. After that, if he is good enough to do research, he is good enough to choose the kind of research that he is going to do.

It is a fairly easy thing to conceive, plan and operate industrial research projects which will give an almost certain 10 per cent return on the research expenditure. It is an even easier thing to devise research organizations of kinds that fall short of doing real research. It is an extremely difficult thing for an administrator to make the grave decisions involved in giving adequate support to the long-term, nearly academic research, which will very probably give a return of some thousand per cent on the expenditures, but which will give that return at a completely unforecastable time and in an almost unforecastable direction.

But, we must insistently emphasize this need for replenishing, extending the stockpile. We have had about a century in which to accumulate the pile. It is beginning to look pretty thin in places, and we have to make sure that there are enough young men and young women turning themselves to the basic kind of research to carry out a replenishment program. The replenishment program is, moreover, constantly becoming more difficult because all the easy things have been done by the people who went before us!

I have said that it is too easy to produce quasi-research organizations; for example, the kind of organization which devotes most of its time to search rather than to research; the kind which carries out the absolutely indispensable task of reading what other people have done, and searching out from what they have done the things that seem likely to make an early contribution to a particular industry. It is a neces-

sary operation, but it is not a sufficient operation and it does not make an industrial research unit. It makes only a bit of one.

Even worse is the kind of research unit in industry which is founded merely in conformity with fashion. I sometimes suspect that units of that kind have their running costs charged to the publicity account. It does happen that that kind of facade is put up, possibly not in United States industry, but certainly in United Kingdom industry; and, after all, I am talking about industrial research in Great Britain. These things require vigilance of the easier kind. I trust, too, that those who go out from this University to build research units of both kinds will not all allow themselves to be seduced into joining the fashionable army of the nuclear scientists. The nuclear scientists are of the greatest importance to the future of civilization. Their importance has two potential signs, as most things have. But they are, again, only a necessary and not an all sufficient component in the over-all research effort.

There is a great need, even in basic research, for people who go back to the classical textbooks on properties of matter, and subjects like that, to advance the intermediate type of knowledge which builds quickly into successful industry.

One of the attractions which is put before the recruit to the academic research field is the opportunity to think: time off—no, not time off; time on duty—to browse, to reflect, to make random guesses and pipe-dreams. It is one of the dangers of the industrial research unit as now visualized that time for browsing and thinking is not readily accorded to the individual industrial research worker. But here again I would say that if an individual is good enough to be a researcher, then he is good enough to be allowed to take thinking time at his own discretion, without having to charge it to a job number. If he cannot be trusted to do that, then he should be fired; or (and I rather suspect this is the more reasonable prescription) the man who does not know well enough how to choose him, to trust him in this way, is the one who ought to be fired first.

These generalities about industrial research would come ungracefully and unproductively from your first alien Howard Lecturer if they were not accompanied by some illustrations from the personal experience of an individual who has had the privilege of participating in a particular branch of industrial research. It happens to have been, in recent years, research for the national and international defense industry, but I believe that our experience in that industry, which was given singularly favored terms of operation in recent years, may have lessons for us in relation to the more permanently constructive operations of peacetime industry.

I ask myself, At what point did radio research become industrial research? Michael Faraday did not sit down with the deliberate intention of becoming the



father of electrical engineering. James Clerk Maxwell repainted Faraday's word pictures with mathematical pigments, not as a contribution to any possible industry, but as his own way of getting down to that "go of things" that he had always wanted to know about. In putting the matter in his own artistic form, he produced new meanings and new extensions of vision for the people to whom he exhibited his mathematical pictures. These emybolist compositions were capable of carrying the scientific mind more quickly, more easily, to new conclusions than were the representationalisms of Faraday's mental imagery.

Popov grounded *his* antenna in order that he might collect radio evidence of the occurrence of lightning flashes. Was that the time when radio research became industrial research? Or was the almost identical moment at which Marconi grounded *his* antenna, in order to improve the communication of human thought, the moment when scientific research in radio became industrial research?

Is ionospheric research any the less an industrial research because in addition to helping us to choose the best frequency it gives us a very great stock of additional information about the terrestrial atmosphere and about the constitution of the solar atmosphere?

Was my own particular hobby of collecting lightning flashes, in some extension from the work which was originated by Popov, an industrial research because it found application in meteorology, or was it basic research on the mechanism of atmospheric electricity?

These are quite pointless questions. All of these things were, in fact, scientific research capable of making contributions to industry, and it really is not worth while examining whether any one of the individuals concerned knew he was doing something about industry or not.

I have to confess that I got in on the ground floor of radar in the United Kingdom because I happened to be the temporary leader of a group of especially privileged young men. These young men, who were gathered together in a small research station, which was set up by His Britannic Majesty's Government, and paid for by the British taxpayer, were told that the communications industry suffered from a considerable number of deficiencies and limitations, and they were told that, having had a preview and a rough outline of these limitations and difficulties, they might usefully turn themselves to the study of the travel of radio waves through the atmosphere; to the detailed examination of what happened to these waves, of the ways, for example, in which naturally occurring waves interfered with the intelligible reception of the artificially generated ones. But—and this was the important instruction—they were told that they need not worry very much about the diseases of radio communication. They were told that they need not, in fact, count themselves as general practitioners attempting to cure the diseases of the communications

patient; they were not even to be pathologists; they were to be the physiologists, the anatomists, the morphologists of the body of radio communication.

They, themselves, were to have their own kind of fun, follow their own kind of hobbies, in the conviction that, if these hobbies were intelligibly and diligently pursued, they would provide the raw material in basic knowledge which would permit application by others to the curing of the diseases of radio communication.

I firmly believe that it was that rather delicate blend between complete academic freedom, in which they need not be told anything about the facts of life, and the too insistent demand that they should produce immediate applications to industry—it was in that nice, comfortable, middle position, between the freedom of ignorance and the shackles of too narrow specialization, that a small group of young men attained the imaginative flexibility of outlook that made them suitable to produce United Kingdom radar just in time for its first crucial application to the industry of defending not only their home civilization in the United Kingdom, but civilization in general.

These young men were good physicists. No one of

(Continued on page sixteen)

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# ALUM NEWS

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*Alumni are urged to keep their friends posted on what they are doing by submitting items of interest for use in these columns. Please include your address.*

The new Blue Plains Sewage Plant has a point in its contention that a branch of the alumni association should be established on the premises, what with so many of this year's graduates working there. For instance, HILLIS McGEE, BCE 49, and GLEN BAL-LOWE, BCE 49, are both working for the District, and JERRY "Peroxide" MICHAEL, BCE 49, is working for the contractor.

CHUCK APPEL, BCE 49, remembered as the chief construction foreman on the inaugural float, can now be found slaving for Alcoa Aluminum, as can TOMMY TATE, also BCE 49.

ED LIPPITT, BME 49, has gone to Charlestown, W. Va. to work with a heating engineer, while his brother RAY stays on in town working for a local patent attorney.

JOHN CHURCH, BEE 48, came back to town long enough to wed Caroline Norfleet. At the risk of coining a phrase, we'll wish you both the best of everything. John has just completed his training at General Electric and BEN CRUIKSHANKS, JR., BME 49, has just started his training with the same organization.

WALT COLE, BCE 49, can be found among the potatoes in Idaho working with the Reclamation Bureau.

ERNEST E. EVERETT, BME 49, 3001 2nd St. S., Arlington, and FRED RITCHIE, BME 49, 9307 Long Branch Parkway, Silver Spring, are with the Washington Gas Light Co. doing gas heating and air conditioning work. Sideline: Ernie substituted for Professor Nye in his air conditioning class for a few days this summer, and was nervous as a brand-new bride before his first class.

FRANK BRAUGH, BME 49, is in the engineer's dream city, Milwaukee, Wis., working for the A.C. Spark Plug plant.

CHUCK MEYERS, BEE 49, is still floating around D. C.—working for PEPCo.

DON BLANCHARD, BCE 49, new business manager of the University, appears to be looking out for our welfare—every light in the Engineering School classrooms works, for the first time in years. Don is also president of the National Capitol Alumni Association of Theta Tau and urges all alumni in the area to contact him. Please do—we need items too.

"Big BILL" ALLISON, BME 49, is in Philadelphia, the City of Brotherly Whatever, working for SKF Ball Bearings. Also in Pennsylvania at the moment is PAT LATTA, BCE 49, who is working on the new addition to the far-famed Pennsylvania Turnpike. Pat's home office is the Grove Construction Co. of St. Paul, Minn.

MATT FLATO, BE 49, has a new cream-colored convertible that has provoked two never-failing comments—take your choice—"watcha doin', writin' numbers?" or "Discovered gold down at the Bureau of Standards?"

RAY JUNCAL, BME 48, paused on his way south to tell us he was now with the Kellex Corp. of Key West.

FRANK W. (Scotty) EDSON, 46-48, 520 N. Dinwiddie St., Arlington, has been working on a project at Vienna, Va. for the Lester V. Johnson Engineering Associates of Arlington, with offices at 2525 Wilson Boulevard. The firm has finished design and undertaken supervision and inspection of installations on the half-million dollar water supply and sewage collection plant.

LESTER LESLIE, BEE 49, 1812 19th St., N.W., is now in the Electrical Engineering Department of Wm. K. Karsunky, Consulting Engineers, here in town. Plug: this firm handles air conditioning, sanitation, and electrical installations, and right now Les is working on plans for the installations in a modern 750-bed hospital, including an eight-story domiciliary. He just completed work on a changeover from DC to AC at the same project.





- Are you studying for a Civil Engineering degree? Is your major Bachelor of Science in Engineering? It is? Well, here is an opportunity that you can't afford to miss, membership in the student chapter of the ASCE.

At our technical meetings we learn quite a bit about engineering that is not included in the regular course of instruction. Q-floors, three dimensional photography, electrical strain gages were some of the interesting subjects discussed last year. In addition we took an interesting field trip to the K-Street overpass. The Annual Conference held in Baltimore last year was one of the high points of a very successful year.

The ASCE takes care of your social life too. Ask some of your friends who are members about the swell time had by all at the spring party. Maybe they can even be coaxed to admit that the engineers who attended were almost as bruised and battered as the Georgetown football team after the GW game.

I could write all day and not tell you of all the advantages of membership, such as "Civil Engineering," the society's monthly publication, and probably the most important, the new friends that you will meet in the course of active participation. You can get all of these by joining at the Engineers' Mixer or at one of the regular society meetings. At a cost of \$3.00 you can secure membership in the society for one year. This includes free parties and a subscription to "Civil Engineering." Don't forget to look for posters advertising the first society meeting.



- The fall membership drive of the George Washington University student branch of the American Society of Mechanical Engineers opens registration day with the distribution of application blanks in the ME section on the third floor of building D.

We've really got something to offer prospective members. Any student majoring in engineering is eligible, including graduate students. The period of student membership is for the fiscal year, beginning October 1st. Dues for the year are \$3.00. Each member receives a membership card, a pin or watch charm, and a subscription through the May issue to "Mechanical Engineering," the official journal of the society.

Among the lucrative privileges of membership are competitions for cash prizes and awards for outstanding papers, use of the Max Toltz student fund (within limits of available funds), and the services of the Engineering Societies' Personnel Services, Inc., in helping to find that elusive job after graduation. Qualified student members who wish to transfer to Junior membership upon graduation obtain suspension of their initiation fee as Juniors upon payment of dues for the first year, thereby saving ten dollars.

Our meetings are interesting and informative, give the student valuable practice in parliamentary procedure and the organization of learned societies, and develop his initiative and public-speaking ability.



- Drop that slide rule, EE! Come out and join your student branch of the American Society of Electrical Engineers at your next opportunity. Meetings are held the first Wednesday of every month during the Fall and Winter semesters. At these meetings you can hear noted authorities on engineering and related subjects, see nearby electrical installations while on field trips sponsored by the AIEE, and (most important) meet your fellow engineers. One of the outstanding annual events is the Spring dinner where the student society meets with the Washington branch to tell them of the society's activities for the year. Another interesting event is the prize paper competition. The students have an opportunity to present some of the knowledge that they have received at GWU in a paper that is judged by members of the Washington branch. The winner of this event has his expenses paid to a later competition between other schools of this division.

It is of vital importance to the electrical engineering student that he avail himself of all the opportunities to develop into an engineer graduate worthy to assume the responsibilities of his chosen scientific field. It was for this purpose that the AIEE student branch was organized at the University in 1932.

Join your local EE society, obtain student membership in the national organization, and reserve the first Wednesday night of every month for attendance and active participation.

Join your local EE society, obtain student membership in the national organization, and reserve the first Wednesday night of every month for attendance and active participation.



- The George Washington University student branch of the Institute of Radio Engineers invites all those students who devote a major part of their time to the electrical engineering curriculum to join our young, growing, and energetic professional society.

Our national organization actively supports twenty-nine college and university branches, and publishes a monthly magazine, "The Proceedings of the IRE." This magazine is chuck-full of interesting, authoritative, up-to-date material which you cannot afford to miss if you are considering the communications option.

The student branch meetings, held on the traditional first Wednesday of each month, feature outstanding speakers on subjects of general interest to electrical engineers. Usually these meetings are held in conjunction with the local professional chapter of the Institute, and student members are welcome at the other professional chapter meeting held each month at the PEPCO auditorium. As you can see, our meetings give you a golden opportunity to meet top men in the field of radio and electronics—a practical aspect for anyone on the look-out for a job after graduation.

We plan to hold at least one field trip a month this year, to points of interest in and around Washington.

Highlights of our social season are the IRE-AIEE baseball game in the spring (we don't always win, but everyone enjoys the game), the annual summer picnic, and the Engineers' Ball and Mixer.



## FRATERNITIES



Sigma Tau Fraternity is a national engineering honor society. Organized forty-five years ago as a local unit at the University of Nebraska, it has expanded until there are now twenty-five chapters at various engineering schools throughout the country. Xi chapter here at George Washington University was installed in 1921.

The membership of the fraternity is drawn from those men whose scholarship places them in the upper third of the juniors and seniors in the engineering school. Selection from these scholastically qualified persons is further based on the qualities of practicality and sociability. Finally, the approval of at least three members of the engineering faculty is required for each man.

As an added incentive to excellence in scholarship, each chapter of Sigma Tau presents a medal to the student (usually a sophomore) who has attained the highest grades during his freshman year. Here at George Washington the award is made at the annual Engineers' Banquet.

In addition to recognizing scholarship Sigma Tau works to give service by joining the various activities of the Engineering School and in certain all-University activities such as the construction of the University's inaugural parade float last winter. Under the leadership of President Bedford Robertson, two projects are planned for the fall. The first is the establishment of an Engineers' Library; the second is the construction of a bracket for a ship's bell to be mounted permanently on the University grounds.

The library, not exclusively a Sigma Tau project, is beyond the embryo stage at the moment, but remains a rather sickly orphan housed temporarily in the engineers' lounge. Cataloguing cards have been made out for the texts collected so far, but no permanent file has been set up as yet. This chore, along with the expansion of the collection, and the major task—that of finding a permanent location for the library—remain to be completed.

The bell is from the World War I troopship *George Washington* and is now in the possession of Professor Johnson of the Mechanical Engineering department. The plan is to locate the bell in some suitable spot, probably in the yard behind the engineering building, in the hope that some tradition similar to that surrounding the statue of Tecumseh at Annapolis

will grow up about it. As a victory bell, it will become an attractive trophy in the eyes of rivals, Georgetown and Maryland for instance. For this reason, although the bracket is not yet designed, it is reasonable to assume that a steel rod with the bolt ends liberally welded over through the eye of the bell will be an integral part of the scheme as a hindrance to those who would snatch the 600-pound trinket.

*Theta  
Tau*

Gamma Beta chapter of Theta Tau is happy to welcome all new Engineering Students to GWU and also glad to see the old familiar faces back on campus.

Theta Tau is a national professional engineering fraternity which recognizes ability, sociability, and activity in the School of Engineering projects and activities. The purpose of the fraternity is to develop and maintain professional interest and to unite its members in the bonds of fraternal fellowship. Each year the fraternity makes an Activities Award to that student who has done the most for the School of Engineering during his entire attendance. Last year the award was made to the then President of the Engineer's Council, Larry Brown.

Membership in the fraternity is by invitation, and several "get acquainted" parties are held each year for prospective members. The prime requisite is activity rather than scholarship, but as our own "Deacon" Ames puts it, "They don't have to be dumb."

Last year's activities were well rounded out by the annual stag party which the National Capitol Alumni Association puts on. This summer found the fraternity cruising down the river on a fishing jaunt at which a long standing record for no fish was broken by brother Bell, who in a loose moment caught a two-foot hardhead.

Plans are already under way on the traditional fall football game and oyster roast to which a minor variation will be added—the alumni have been challenged to a game with the actives with a suitable prize for the victors.

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*(Continued from page twelve)*

us would have classed himself as a first-rank physicist, but we became (I claim it without undue modesty) good industrial researchers, precisely because we were aware of the demands of industry without having been held down too tightly to the immediate meeting of these demands.

In a country where the operations and instructions of the federal government are viewed with feelings that vary between exaggerated objection and amused tolerance, I must repeat, with some emphasis, the statement that I have already made: that the pre-radar operations of these privileged young men were entirely supported by the federal government of the United Kingdom. United Kingdom radar, for what it was worth, was the product of an already nationalized industry!

But that was not the sole example in our radar history, in this particular industrial research, where the industrial application was enormously accelerated by the special availability of people with the fundamental research mind. Far more than in the initial stage were we indebted to the real, first-rank physicists, whom we drew, in the spring of 1939, from the pleasant fastnesses of the British universities and the senior schools; whom we took, with their cordial concurrence, and pushed into the front lines of our growing defense system so that they might see, in the field, the exact nature of the demands of this defense industry.

These people, who had been skilled in atomic, molecular, and electronic physics, were, in the highest degree, possessed of this imaginative flexibility which, as I keep insisting, is the essential tool of the industrial researcher, as well as of the academic researcher. They were able to return from the operational field station, on the designed coastline, to their laboratories, and to bring out from the laboratories, in an astoundingly short time, that resonant cavity magnetron which revolutionized radar, and which became the foundation of the tremendous wave of radar advances achieved, alike, in this country and in my own country.

I will not point to any one moral in this brief story of how the academic researcher turns out to be one of the best of industrial researchers. I think there is a pretty considerable range of morals which one ought to examine at some leisure. I am sure that, amongst the morals, the most important is that real industrial research has to go right back to the roots, that tinkering with process is wasteful compared with a return to the fundamentals. It is for these, among many, reasons that I see an increasing need for continuous interchange of thought, by direct personal meeting, between the basic researcher and the man who is researching for early application. But these things belong to the field of afterthought, toward which I seek to make no other contribution than to put before you things that must have their counterpart in your own experience, but in which the happy interchange of knowledge and aspiration and thought, now going on

so actively between our two countries, requires supplementing and extension by internal interchanges amongst our own scientific workers.

I have said that this radar development in the United Kingdom was one which emerged from a government research institution. It has been my purpose, in giving that indication of Chapter 1 in our own radar history, to lead you to look with me at some other aspects of research, industrial research, in the United Kingdom, which at least find a different emphasis on the two sides of the Atlantic.

The National Physical Laboratory, which is, in some measure, the counterpart of your National Bureau of Standards, is the oldest and best known of a quite considerable number of government research institutions and stations which are wholly owned, administered, and directed by government, with the advice of councils drawn from among the most distinguished scientific workers of the country.

Beyond the National Physical Laboratory, we have a group of stations which you will identify as being concerned with those improvements in our knowledge of science which go toward meeting the basic requirements of a tolerable existence. We have, alongside the National Physical Laboratory, a Chemical Research Laboratory, and we have, spreading out from these centers, a Building Research Station, and a group of three Food Research Stations, one concerned with low-temperature preservation of food, one especially concerned with those improvements in our knowledge with the fruit industry.

We have a Forest Products Research Laboratory; a Fuel Research Station; the Geological Survey; the Pest and Infestation Station, again, concerned with the conservation of our food resources; a Road Research Station; and a Water Pollution Station. You will see there the attempt to accelerate the contributions of science to our basic needs, of being sheltered, warmed, fed, and moved about to pursue our more or less useful avocations.

But the particular government-supported industrial research organizations which certainly find a counterpart here on a substantial scale, but find with us in Great Britain a much larger share of support from government funds, are the Research Associations, and I would like to talk about these associations against a very superficial survey of what we are all spending on scientific research. I make no apology for being a few million dollars out in any of the figures that I give you in this rough background picture.

You in the United States were, within the last year or two, spending on scientific research for military and civil application something of the order of 1 billion dollars per annum. At about the same time, we in Great Britain were spending about a quarter of a billion, France was spending a tenth of a billion, and the countries participating in the plans for a western European grouping were, in total, spending a sum which may have been in the region of three-quarters of a bil-



lion U. S. dollars. If there is any uncertainty about what I mean by the U. S. dollar, I have converted my sterling estimate into U. S. dollars at the rate of \$4 to the pound.

Within the United Kingdom, as I have said, we were spending a sum that I would make a little more precise now by calling it 275 million dollars, on military and civil research. The civil part of that expenditure was 35 million dollars. To these sums there should be added another 30 million dollars, given in university grants out of public funds, but at the unfettered disposal of the scientific research units and the scientific sections of the universities. This 30 million dollars is to be added to the previous total of the order of a quarter of a billion.

From industrial sources outside government, we can get, I think, a fairly close estimate that industrial research in the United Kingdom, within industry itself, was costing about 120 million dollars per annum, that is to say, about two-thirds of one per cent of the value of the manufactures of the United Kingdom of that date.

That research was employing about ten thousand professionally qualified men, that is, of degree standard or its equivalent; and, by and large, the units were costing annually eight thousand dollars per qualified man over the greater part of the field, but, in the special field of aerodynamics, they were costing about \$36,000 per qualified worker. There was this very large ratio, of the order of four or four-and-a-half to one, between the average cost of nonaero research and aero research, even in the years of 1946 and '47.

Within these totals, then, there were found sums for the support of cooperative research associations, which were set up in this way. The research associations were under the general aegis of the Department of Scientific and Industrial Research, and it is perhaps not inappropriate to remark that the foundation of that government department, and the conception of these government-aided cooperative research institutions, found their roots and a great deal of their initial sustenance in the minds of a very great Liberal statesman, Lord Haldane, and of a very great Conservative statesman, the late Lord Balfour, A. J. Balfour. It was under their successive inspirations, in the middle of the 1914-18 war, that the Department of Scientific and Industrial Research was founded, and that the first industrial research associations of the kind that I am now discussing were set up.

A couple of years ago, these associations had an income from member firms of 5½ million dollars per annum, and on a rather complicated scale, from government subventions of about 4½ million dollars; together with other trifles of income, these research associations had a total income of 9½ million dollars per annum.

They were, as I said, under the general aegis of the government department. They had a minority part of their income from government funds, but they en-

joyed complete industrial autonomy. A small firm could attain membership by the payment of a sum which would not have bought them a single scientific worker, and the associations appointed their own council; the government department took to itself no further power than the right to appoint two independent outside scientists, not in government employment, to these councils, if it saw fit. The associations were empowered to set up their own programs of research, and to accept paid confidential work from member firms. This latter they do on lines that are familiar to you here in relation to your own fellowship institutions, but with a substantial difference. If you asked one of your fellowship institutions whether, faced with a choice between doing specific fee-paid work for an outside unit in industry and general basic work the U. S. institution would usually, I think, reply that it would give priority to the limited and paid project. The United Kingdom research association would quite certainly give priority to the general investigation and only fit the limited and paid projects into the moments in which the workers could turn from the more general investigations without detriment to them.

Such associations were set up in (I will not run through the whole list but it is almost an alphabet of industry) the boot and shoe industry, the cast iron industry, in coal utilization, in cocoa chocolate and confectionery, in coke (in the nonconfectionery sense), in the colliery industry, in cotton, in the electric industry, for the flour miller, the food manufacturers, the gas industry, the internal combustion engine, iron and steel, in jute, laundry, leather, linen, motor and allied manufacture, nonferrous metals, paint, paper, pottery, printing, production engineering, rayon, refractories, rubber, scientific instruments, shipbuilding, welding, and woollens.

I will not attempt to pull out any plums of industrial triumphs resulting from the work of the associations. There are some pretty good plums, but I believe an adequate general test of the usefulness of these institutions is to be found in some data collected by my friend Mr. R. S. Edwards, of the London School of Economics, data which he is about to embody in a work which I believe will be read with considerable interest in this country, as in Great Britain.

He has addressed questions to, and had comparable replies from, a very representative sample of the participating firms in these research associations. Perhaps I should say that the research association is designed to be merely supplementary to the possession by the member firm of an active research and development unit of its own. The firm that can benefit best from the work done by the research association is clearly that firm which is readiest to put into its own research and development unit the information that it gains from the general research, and to carry it forward, on a narrower front, for the satisfaction of the objectives of the individual member firm. It is, in fact, in the highly competitive industries that the re-



search association can give help which is most valuable to the individual competing firm.

Of the firms in the United Kingdom which are spending more than four thousand dollars a year on research (a figure which is used merely to exclude the people who cannot be getting more than the work of a single junior worker), 90 per cent of all the firms which exceed that one thousand pound sterling expenditure on scientific research have their own internal, independent laboratories. Three-quarters of these firms are members of a research association, and more than half of them are members of more than one research association. Two-thirds of them want an extension of the exchange of information amongst firms in the same field.

You must be familiar with the old delusion amongst many industrial concerns that they had some priceless jewel of secret information which must not be shared with their competitors. Wartime interchange has brought a good many of these jewels under the ultra-violet light which reveals their degree of preciousness, and it is an advance in our education that such a big majority of our firms believe that they would benefit, as would their competitors, by an exchange of industrial information.

Mr. Edwards put to a sample of the firms the simple question: "Do you regard your subscription to your research association, or associations, as a good investment?" Two-thirds of them said, unhesitatingly and clearly, "Yes, it is a good investment."



He said, then, "Do you have clearly in your mind, and without rummaging 'way in the back spaces, a specific example of a valuable result which you have got from your research association?" and, again, two-thirds of them said "Yes."

He said, "Do you think the research association activities should be expanded?" and, again, two-thirds of them said "Yes."

There was one industry in which the research was financed by a compulsory levy on the turnover of the industry concerned, and he said to all the firms, not only to those in that industry but to the fully representative sample, "Do you think the financing should be done by compulsory levy?" and two-thirds of them said, "No, certainly not." That, I believe, is one of the most illuminating indications of the fact that the individual firm thinks it is getting a good investment, because it is putting its own money into getting a result which it can control through the democratic operation of the council, the association's own elected council.

You may, sir, think that I have been delivering the prologue to an address on the beauties of nationalization in Great Britain. I can only repeat that amongst the associations which I have enumerated to you, the founder associations, so to speak, those on scientific instruments and on woollens, were founded as far back in the prenationalization era as the year 1918, and there were founded in 1919 those in the boot and shoe industry, in the confectionery industry, in cotton, in linen, in motor and allied manufacturing, in nonferrous metals, and in rubber. These are all old-established institutions, but they are far from senile institutions.

There is, sir, no epilogue to this talk. There would be no end to it if I had not learned some of the humanities; I have strained your tolerance far enough. I would like to say again, more explicitly, how profoundly I appreciate the honor you have done me in inviting me to speak from a very closely friendly nation in this series of most important annual lectures on the industrial research which is to determine the future happiness of the world.

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(Continued from page seven)

graph must be capable of reproducing both the pure and complex sound components exactly as to pitch and intensity. Intermodulation or harmonic distortion in any part of the system will create new frequencies and destroy the fidelity of reproduction. Resonance can occur in any mechanical system containing inertia and elasticity, therefore transient complex vibrations are often set up when a constant driving force is applied to a crystal pickup. This is reduced to a minimum with the permanent sapphire point pickup used with the 45 rpm system. The smaller inertia of this type of point, compared with the old style removable needle, results in better damping, making equalization of the output possible. Equalization is the correction of intermodulation frequencies resulting from the mixing of transient oscillations produced by resonance in the pickup arm with the signal frequencies in the presence of non-linearity in the amplifier. This is usually done by the use of negative feedback applied to the pickup circuit. Each of the two general types of feedback, voltage and current, tend to make the voltage output a replica of the signal voltage.

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### **Economic Factors**

The announcement that RCA Victor planned to place a new and radically different type of phonograph record and record changer on the market stirred a controversy in the radio and record manufacturing world. Columbia Records had brought out a Long Playing Microgroove record in June, 1948. RCA's machine had many of the same advantages that the Columbia system had, including microgrooving, reduced speed, and high-fidelity tone quality. Columbia had sold 500,000 long playing attachments and 2,000,000 records by that time. Its record speed is 33 $\frac{1}{3}$  rpm, maximum playing time for a stack of records about four hours, and its changer can be used for ordinary 78 rpm records with the use of a two speed motor and extra tone arm. The Columbia records are made in three sizes: 12 inches playing 25 minutes; 10 inches playing 15 minutes; and 7 inches playing 8 minutes. Both companies have released all blueprints and specifications on a royalty-free basis to all manufacturers who wish to manufacture the new phonographs and records. From the sidelines it appears that Columbia and Victor will have a market fight, something that retailers fear because of the impact on trade by indecision on the customers' part.

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### **Presidential Derby Bulletin**

● The following very surprising statistics are quoted from the September issue of Magazine Digest as a boost to Engineering School morale:

"It might be thought that business college graduates would form the largest single group of high executives. Strangely enough, a study of the educational background of 150 corporation presidents shows that graduates of commerce and business colleges and business administration courses occupy only 7% of the presidencies.

"Men with only 'common school' education comprise 50% more presidents than these 'specially trained' graduates. Even more surprising, one out of every three presidents is a graduate engineer."



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